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Neighbors in Need: CIRA Technologies Help in Hurricane-Prone Central America

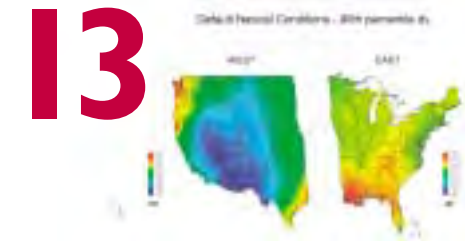
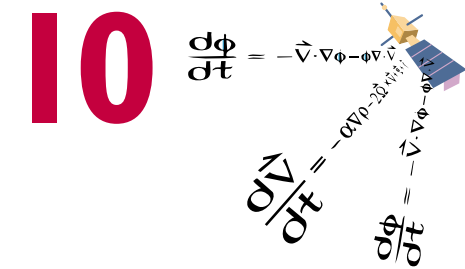
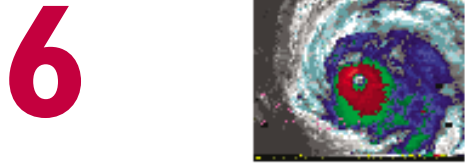


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Knowledge to Go Places

VOLUME 16, FALL 2001

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International Activities and Hurricane Mitch Reconstruction Efforts

By Bernadette Connell and Mark DeMaria

This past July, Global Imaging Inc., under contract with NOAA/NESDIS, installed a GOES-8 satellite receive ground station and server at the Instituto Meteorológico Nacional (IMN) in San José, Costa Rica. The picture on the cover of this

edition of the newsletter shows the ribbon cutting ceremony that took place on July 26 at IMN in Costa Rica. The server will make GOES-8 digital satellite imagery and products available to the surrounding six Central American countries (Panama, Nicaragua, Honduras, El Salvador, Guatemala, and Belize) for use in real-time forecasting efforts. By the time you read this article, each of the surrounding countries will have received a RAMSDIS (Regional and Mesoscale Meteorology Team Advanced Meteorological Satellite Demonstration and Interpretation System [Molenar et al., 2000]) system to ingest and display the imagery.

History

The U.S. Agency for International Development provides



Gregory Withee (left), NOAA/NESDIS Assistant Administrator for Satellite and Information Services and Eladio Zárate (right), Director General of IMN.

funding for this effort through the NOAA/NESDIS/CIRA RAMM team to improve forecasting capabilities in the region in response to the devastating effects of Hurricane Mitch in October 1998. This article chronicles the RAMM team's international efforts that led to the installation of the satellite
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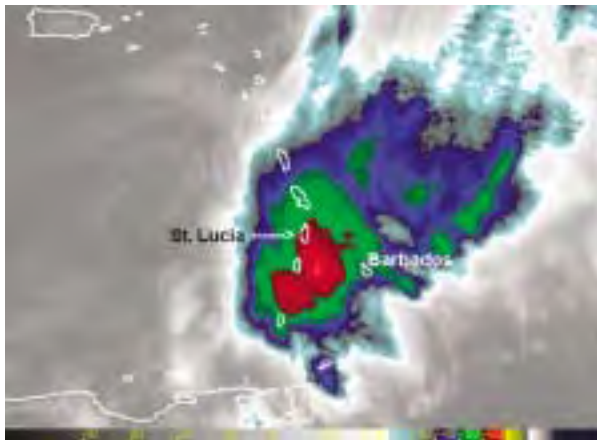


Figure 1. GOES-8 average 10.7 μm image covering the period 12:15 – 18:15 UTC on October 26, 1996 when St. Lucia received 250mm (10 inches) of rain.

Fellowships in Atmospheric Science and Related Research

The Cooperative Institute for Research in the Atmosphere at Colorado State University (CIRA) offers a limited number of one-year Associate Fellowships to research scientists including those on sabbatical leave or recent Ph.D. recipients. Those receiving the awards will pursue their own research programs, collaborate with existing programs, and participate in Institute seminars and functions. Selection is based on the likelihood of an active exchange of ideas between the Fellows, the National Oceanic and Atmospheric Administration, Colorado State University, and CIRA scientists. Salary is negotiable based on experience, qualifications, and funding support. The program is open to scientists of all countries. Submitted applications should

include a curriculum vitae, publications list, brief outline of the intended research, a statement of estimated research support needs, and names and addresses of three professional references.

CIRA is jointly sponsored by Colorado State University and the National Oceanic and Atmospheric Administration. Colorado State University is an equal opportunity employer and complies with all Federal and Colorado State laws, regulations, and executive orders regarding affirmative action requirements. In order to assist Colorado State University in meeting its affirmative action responsibilities, ethnic minorities, women and other protected class members are encouraged to apply and to so identify themselves. The office of Equal Opportunity

is in Room 101, Student Services Building. Senior scientists and qualified scientists from foreign countries are encouraged to apply and to combine the CIRA stipend with support they receive from other sources. Applications for positions which begin January 1 are accepted until the prior October 31 and should be sent to: Professor Thomas H. Vonder Haar, Director CIRA, Colorado State University, Fort Collins, CO 80523, USA. Research Fellowships are available in the areas of: **Air Quality, Cloud Physics, Mesoscale Studies and Forecasting, Satellite Applications, Climate Studies, Model Evaluation, Economic and Societal Aspects of Weather and Climate.** For more information visit www.cira.colostate.edu

International Activities *(continued from page 3)*

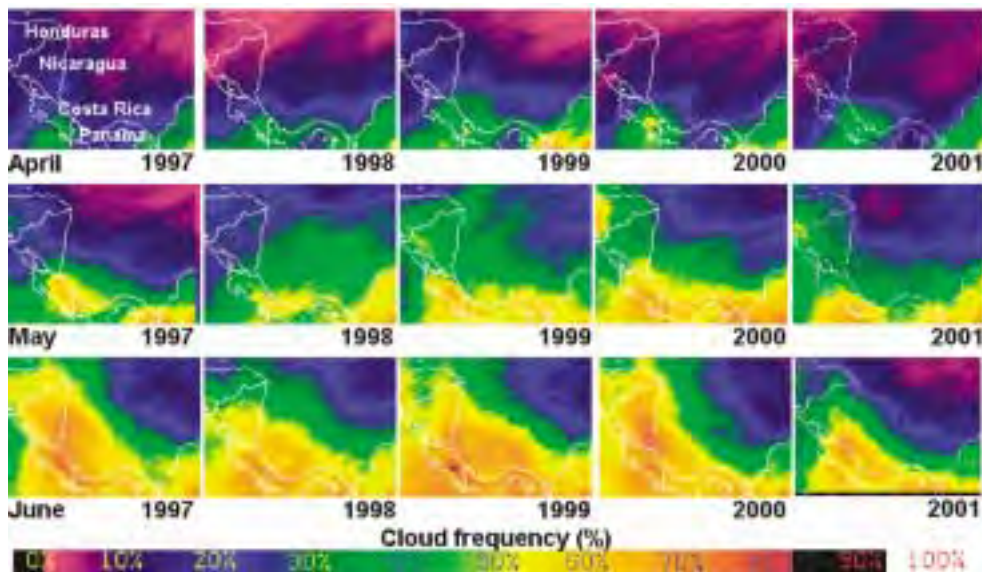


Figure 2. Monthly cloud frequency derived from 10.7 micron GOES-8 imagery using a temperature threshold of 273 K (includes hourly images from 00:15 – 23:15 UTC). The months of April, May, and June show the transition from the drier to wetter season.

lite ground station in Costa Rica and Personal Computer (PC) based ingest systems in the other countries, and includes training efforts on the use of the satellite imagery.

CIRA's interaction with Central American and Caribbean countries began before Hurricane Mitch. Interaction was undertaken in 1996 in the spirit of the 45th session of the World Meteorological Organization (WMO) executive council which recommended that "each satellite operator ... cooperate with at

least one of the specialized satellite applications training centres ("centres of excellence") strategically located around the globe with regard to the satellite programme, facilities and expertise required" (Purdom, 1997). Under this activity, CIRA partnered with NOAA's Cooperative Institute for Meteorological Satellite Studies (CIMSS) and the Regional Meteorological Training Centers (RMTCs) in Costa Rica and Barbados.

The RMTC in Costa Rica is closely asso-

ciated with the Universidad de Costa Rica, and Dr. Vilma Castro Leon has been the driving force behind their activities. The RMTC in Barbados is closely associated with the Caribbean Institute of Meteorology and Hydrology and Mr. Selvin Burton and his brother Horace have been leading the efforts in the Caribbean. The project was designed around the concept of the virtual laboratory, which focuses on using PCs, case data sets, and Internet connections to demonstrate the invaluable use of digital satellite imagery. Many Central American, Caribbean, and South American countries currently only receive satellite imagery in picture format at infrequent time intervals.

Activities

Since the inception of the program, many sets of retrospective digital satellite imagery have been provided to both Costa Rica and Barbados. These case studies include heavy rain events associated with hurricanes at different stages of development and heavy rains associated with major tropical waves (Fig. 1: heavy rain case for St. Lucia). Other case studies demonstrated cycles of convective development over land and water, strong wind events, fire detection, and volcanic ash detection. The case studies have been used for training on the use of single and multi-channel imagery in detecting fog, water, and

(continued on page 5)



Figure 3. Participants and instructors for the one-week training held in April 2001 in Costa Rica.

International Activities *(continued from page 4)*

ice cloud, and on the use of applications such as image averaging and determining cloud motion winds. In addition to these case data sets, a major effort was initiated in Costa Rica in November 1996 and in Barbados in February of 1998 towards developing localized satellite climatology archives (Fig. 2: example of cloud frequency for Costa Rica).

Training

In October of 1998, the World Meteorological Organization sponsored a two-week satellite meteorology training event in Barbados. Researchers from CIRA worked closely with the RMTC in Barbados to develop the training schedule and prepare and deliver lectures and hands-on laboratories. Prior to the training, talk had begun on upgrading satellite imagery receiving capabilities in Central America, the Caribbean, and South America. With adequate Internet connections, the low-cost PC-based RAMSDIS system, which was successful in NWS offices in the U.S. prior to AWIPS deployment, was the perfect candidate for distribution. However, Hurricane Mitch developed near the end of October 1998, and had devastating effects on many Central American countries. The focus of PC deployment at this point quickly changed to reconstruction efforts for five Central American countries: Guatemala, Honduras, El Salvador, Nicaragua, and Costa Rica.

Hurricane Mitch Recovery Efforts

Part of the CIRA/NOAA reconstruction efforts include installation of a ground receive station in one of the countries and serving the data through the Internet to the other four countries. Officials from CIRA, CIMSS, and NOAA/NESDIS traveled to the five countries in October of 1999 to determine the most suitable location to receive the ground station. They discovered that the countries belong to a regional organization and this organization had recommended that the ground station go to Costa Rica. Costa Rica had an existing antenna with a ground station that displayed the imagery in TIFF format. They also had the best infrastructure to support the project. The regional organization also asked that Panama and Belize be included in the project.

In December of 1999, another WMO sponsored two-week satellite meteorology training event was held in Costa Rica. As with the previous training, researchers from CIRA worked closely with the RMTC in Costa Rica to develop the training schedule and prepare and deliver lectures and hands-on laboratories. The Mitch Project took advantage of the opportunity and sponsored participants from the Central American countries.

In many Central American countries (as well as other Caribbean and South American countries) resources are limited for monitoring the weather. There are no daily soundings, no radar facilities, and a dearth of rainfall monitoring stations. Another part of the Mitch Recovery effort was directed towards adaptation of satellite techniques to better identify and quantify heavy rain events. A CIRA visiting scientist, Rosario Alfaro, from the IMN in Costa Rica, was selected to work with the NOAA/NESDIS Hydrology Team in Camp Springs, Maryland, to adapt the satellite-based rainfall techniques (primarily the Autoestimator [Vicente and Scofield, 1998]) for Central America. Rosario has been in Maryland since August 2000 and will continue working there through December 2001.

After a few project delays, a contractor, Global Imaging, was selected in February 2001 to purchase and install the satellite ingest system and data server at the IMN in Costa Rica. As actual installation dates became eminent, a one-week training was conducted during the last week of April (Fig. 3). To build on the information learned in the previous training, each country was asked to send the same participants that attended the December 1999 training. The highlights of the training included review of the GOES Imager channels and their applications, the Autoestimator and its results for last year's Hurricane Keith, and the detection of fires and volcanic ash using satellite imagery.

A final Mitch training is scheduled for the first week in December 2001. Working with Central American countries has had its rewards and frustrations as well as its lessons as cultural and language differences were brought to the surface (the primary language is Spanish). Regular mail delivery is not trusted, so FEDEX had to be used for all mailings. The fast Internet connections the

U.S. enjoys do not cross the borders. Still, the forecasters in the various countries are eager to receive the RAMSDIS systems and learn how to better utilize satellite imagery in their everyday forecasting tasks. Funding from the Mitch Project will end in December 2001, but interactions between CIRA and both the RMTCs in Costa Rica and Barbados will continue.

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Hurricane Research at CIRA

By Ray Zehr

In August of this year, NOAA's Hurricane Research Division warned residents of the U.S. Atlantic and Gulf coasts to be aware of an escalation in tropical storm activity. As reported in an article³ in the July 20, 2001 issue of *Science*, this increase is due in large part to a multi-decadal cycle of climate change, with active Atlantic hurricane seasons expected to be prevalent for several more years. CIRA / RAMM research scientists are pursuing a variety of applied research topics and product development goals aimed at improving tropical cyclone forecasts. As the number of dangerous cyclones and hurricanes increases every year, this kind of information is invaluable to weather forecasters and disaster management officials alike.

The emphasis of CIRA / RAMM team research currently underway is on optimizing the information content of satellite sensors and images. For example, recent advances in satellite microwave sounders have been used to produce independent measurements of hurricane pressure and wind fields. Figure 1 shows analyses of Hurricane Floyd (1999) using the Advanced Microwave Sounder Unit (AMSU) on the NOAA polar orbiting satellites that provides unique measurements when it passes over a hurricane.

Another CIRA / RAMM project is archiving infrared images over all tropical cyclones through their entire life cycle in a common format. The 4 km resolution images at 30-minute time intervals capture important track and intensity changes. The enhanced infrared GOES images of the Atlantic hurricanes that attained a Saffir-Simpson¹ Category 3 or higher intensity², during the six-year period, 1995-2000 (Figure 2) were obtained from that archive. The images are centered on the hurricanes near the time of their maximum intensity and all have the same resolution and projection for accurate comparisons of features such as eye size among the different hurricanes. Figure 3 shows where they were located. Fifteen of the 23 hurricanes made landfall with at least hurricane intensity, and eight of them were intense hurricanes when they came ashore. Seven of the 23 hurricanes hit the U.S.

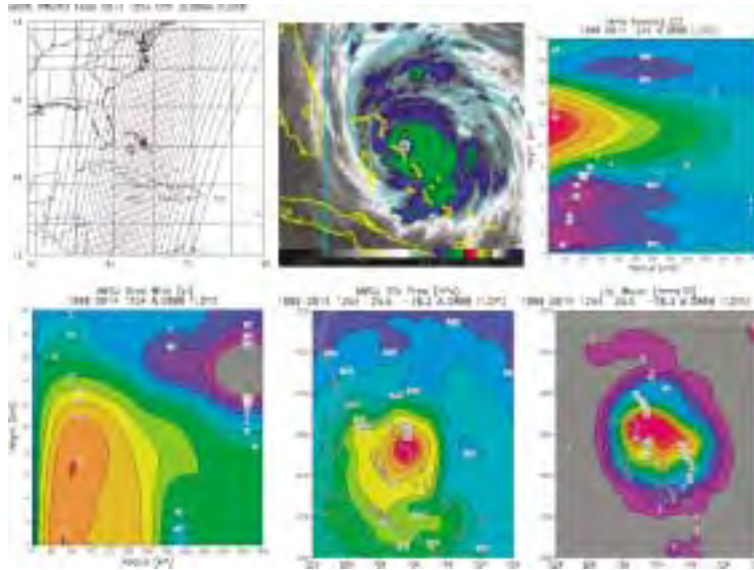


Fig. 1. AMSU analyses of Hurricane Floyd: upper right, vertical cross-section of temperature anomaly. Lower left, vertical cross-section of gradient wind. Lower center, surface pressure. Lower right, vertically integrated liquid water. Upper center, color enhanced GOES IR image at time of AMSU pass. The locations of the AMSU fields of view and the hurricane center location are shown in the upper left.

The increase in Atlantic hurricane activity in recent years is confirmed by the numbers. During the six-year period, 1989-1994, there were only seven intense Atlantic hurricanes compared with the 23 that occurred in the period 1995-2000. Clearly, the type of data collected and the tools being developed by CIRA / RAMM researchers is both critical to the coastal residents of the U.S. and to the nation at large. As CNN recently reported, an insurance industry study found that damage from a hurricane could cause \$20 to \$50 billion in damage to a major coastal city. And if one was to make landfall in a heavily populated area, thousands of people could die. The life-saving potential of the work being done by the CIRA / RAMM team is clear.

²“Intensity” is expressed as the best estimate or measurement of the highest wind speed at any location within the hurricane, calibrated to one-minute average wind at 10 meters height.

³Goldenberg, S.B., C.W. Landsea, A.M. Mesta-Nunez, and W.M. Gray, 2001: The recent increase in Atlantic hurricane activity: Causes and implications. *Science*, 20 July 2001, 293, 474-479.

(continued on page 7)

¹Hurricane Intensity categories according to the Saffir-Simpson Scale are widely used. They relate to maximum wind speed as follows: Category 1: 74-95 miles per hour (mph). Cat. 2: 96-110 mph. Cat. 3: 111-130 mph. Cat 4: 131-155 mph. Cat.5: more than 155 mph.

Hurricane Research *(continued from page 6)*

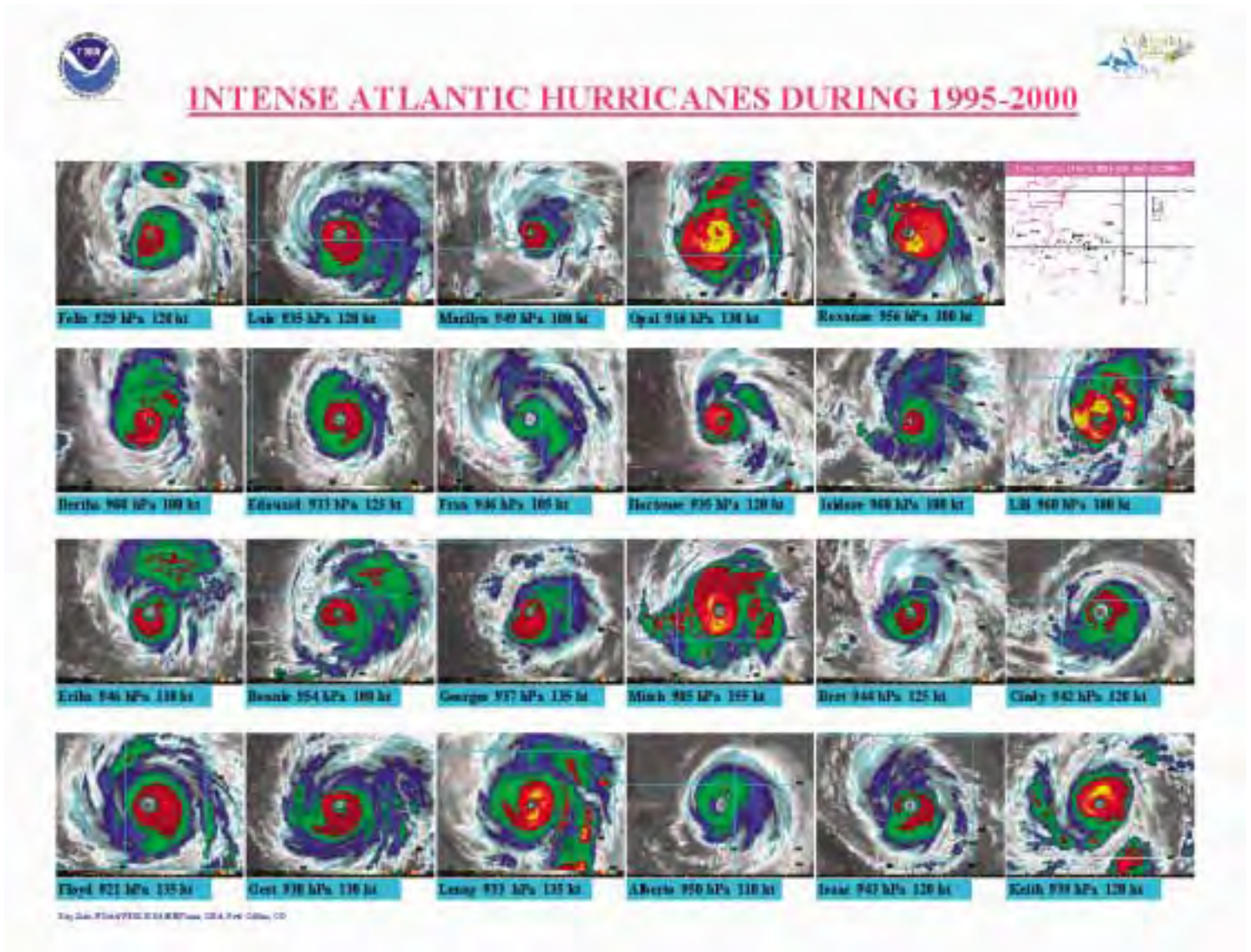


Fig. 2. Color enhanced GOES IR images at time of maximum intensity for the 23 intense Atlantic hurricanes during 1995-2000.



Fig. 3. Locations and names of the 23 intense Atlantic hurricanes during 1995-2000, at maximum intensity.

Ultraviolet-B Radiation Measurements and Research

By Wei Gao and James R. Slusser

There has been growing concern lately about the possible impact of ozone-layer depletion because the stratospheric ozone is one of the primary attenuators of solar ultraviolet-B radiation (UV-B region, between 280 and 320 nm). A decrease in stratospheric ozone would lead to increases in UV-B irradiances reaching the earth's surface. Excessive UV-B radiation burns human skin and is the main cause of skin cancers, cataracts, and immune-system damage to humans and animals. It can also cause mutation and permanent harm to plants, forests, and entire ecosystems. Even materials used in daily living, such as plastics and paints, will deteriorate from exposure to UV-B radiation. The effects of UV-B enhancements on plants include reduction in yield, alteration in species competition, decrease in photosynthetic activity, suscepti-

bility to disease, and changes in plant structure and pigmentation (Caldwell et al., 1998; Madronich et al., 1998). About two-thirds of some 300 species and cultivars tested appear to be susceptible to damage from increased UV-B irradiance.

Monitoring UV-B Levels

The United States Department of Agriculture (USDA) UV-B Radiation Monitoring and Research Program (Bigelow et al., 1998) began installing the UV Multi-Filter Rotating Shadow-band Radiometer (UV-MFRSR, Yankee Environmental Systems, Turners Falls, Massachusetts) for long-term measurements of UV radiation in 1995 and now has 28 sites across the U.S., as well as two sites in Canada (Fig. 1a, 1b). Its mission is to measure accurately the UV-B at ground and to develop a UV-B climatology



Figure 1b: The shadow-band radiometers use a computer-controlled, automatic rotating shadow-band, which determines near-simultaneous measurement of total horizontal, direct normal, and diffuse radiation at each filtered passband. The broadband UV meters measure ultraviolet radiation in the UV-B spectral range of 280-330 nanometers.

USDA UV-B Radiation Monitoring Network Climatological Sites



Figure 1a: Every 20 seconds, remotely driven shadow-band spectrometers at 28 U.S. rural sites and two Canadian sites take readings of ultraviolet radiation reaching the ground. These uniform, standardized UVB measurements are then posted to our Web site the next day.

and critical data to support research on the effects of UV-B on plants, humans, animals, and materials. In addition, program scientists participate in research projects designed to increase the understanding of the impacts of ultraviolet radiation on agriculture, as well as human and ecosystem health. Through this network, we can provide comparable, standardized measurements of ground UV-B radiation. Since the UV radiometer measures the direct Sun radiation, the relative contribution of clouds, ozone, and aerosols to the attenuation of UV-B can be determined with network data. A method for direct-Sun column ozone retrieval using the UV-MFRSR was developed and validated by Gao et al. (2001a). Automated field calibrations are routinely performed using the Langley method (Slusser et al., 2000). The UV synthetic spectra retrieval model developed by the program is used to estimate the continuous spectral dis-

(continued on page 9)

Ultraviolet-B Radiation *(continued from page 8)*



Figure 2: Tested plants were growing in contrasting UV-B environments at the University of Maryland.

tribution based on the multiple UV radiometer channel measurements (Min and Harrison, 1998). Comparisons of these synthetic spectra with the spectra measured from a

USDA Reference UV spectroradiometer and the NIWA (National Institute of Water and Atmospheric Research, New Zealand) UV spectroradiometer were conducted (Gao et al., 2001b). Comparison between these three data sets can be used to assess the ability of the UV synthetic spectra model to accurately retrieve solar ultraviolet irradiance from UV-MFRSR measurements.

Evaluating UV-B's Effect on Crops

Better understanding of the effects of elevated UV-B on crops calls for more complete and precise studies of how UV-B affects various crops. This knowledge will enable us to develop solutions that will allow plants to cope with these effects and ensure crop productivity. Studies like these, conducted in partnership with the nation's leading UV-B agricultural researchers, are an important component of the USDA UV-B Monitoring and Research Program. To evaluate the amount of UV-B stress in various plant canopies and under different sky conditions requires a three-dimensional (3-D) model. Our research resulted in a 3-D UV Radiation Transfer model, which calculates the amount of UV-B radiation passing through a canopy at any location within or below an open vegetation canopy (Gao et al., 2001c; Gao et al., 2001d). We are presently working with the research group at Mississippi State University to study the effects of enhanced UV-B on cotton growth, development, and yield. One outcome of this research will be the development of computer models of UV-B radiation effects on cotton physiology and growth. Our intent is to incorporate this model into the existing cotton simulation model to predict

cotton responses to future climate change, including UV-B radiation – information that can be used for impact assessment and analysis, as well as policy decisions.

In our studies with a research group at Purdue University, we are evaluating the risk of soybeans to enhanced UV-B. We expect these research results, combined with USDA UV-B Monitoring and Research Program measurements, will enable us to provide potential UV-B impact maps for various cultivars across the soybean growing region. We are studying how UV-B affects leaf development and chemistry, as well as the level of DNA dimers produced in plants growing in contrasting UV-B environments (Fig. 2) with the research group at the University of Maryland. The plants we are testing are soybeans, cucumbers, and melons. This research will help us to better understand the plant mechanisms of UV-B responses.

In working with a research group at Colorado State University, we are looking at short-grass steppe to determine the effects of UV and moisture on plant litter decomposition. This study will investigate the interaction of UV and carbon in the soil – data that is critical to current studies of ways to mitigate global warming by reducing carbon dioxide emissions.

Producing a UV-B climatology and collaborating with agricultural researchers to study the effects of UV-B radiation on plants, are the first steps to minimizing its damaging effects to food and fiber supplies. We are focused on enhancing our understanding of factors that control ultraviolet radiation and on improving the quality of UV-B monitoring instruments and data. We work both alone and in tandem with other prominent UV scientists on research that contributes to solutions that will help ensure the long-term viability of this nation's agriculture. The data we generate is of great value to those who now use it, and it will continue to be used by atmospheric scientists and remote-sensing specialists, as well as by health-effects researchers and in pollution studies, thus contributing to the health of our population.

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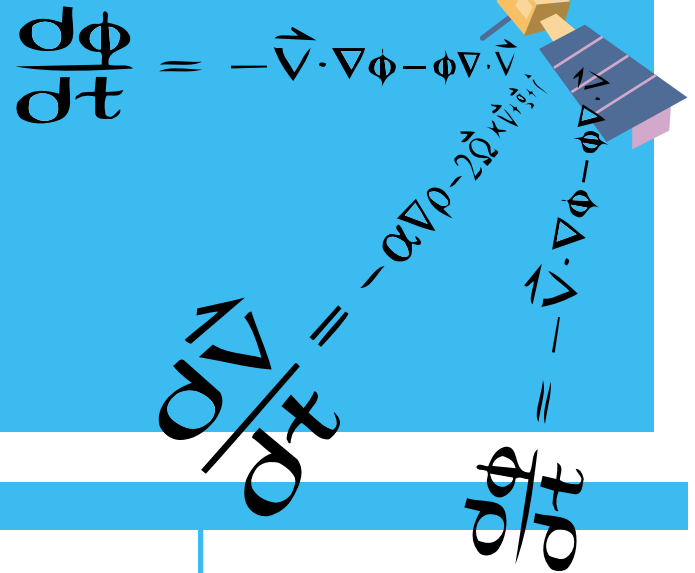
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Two of a Different Kind: Merging Models and Satellites for Better Weather Predictions



By Tom Greenwald and Mary McInnis

Ever since the launch of the first weather satellite, scientists have tried to use the information beamed back to earth from these space-based observers in improving their weather forecasts. While significant technological advances have been made over the years, only a fraction of the data currently transmitted by weather satellites is actually used in forecast models. Many obstacles have impeded their inclusion, but a team of scientists here at CIRA has been developing some of the most cutting edge solutions to bring together weather forecast models and satellite observations.

With funding provided by the Department of Defense through the Center for Geosciences Atmospheric Research, the science team has been working for nearly three years on the project. Team leader, Dr. Tomislava Vukicevic, manages the effort with her team including Drs. Duska Zupanski and Milija Zupanski, both formerly of the National Centers for Environmental Prediction (NCEP), and Dr. Tom Greenwald. The initiative involves the use of CSU's widely known Regional Atmospheric and Modeling System (RAMS) as the core forecast model and has focused on exploiting data from the Geostationary Operational Environmental Satellite (GOES) instruments under all weather conditions. This past July, Dr. Vukicevic and her colleagues presented their latest research results at the 8th Scientific Assembly of the International Association of Meteorology and Atmospheric Sciences that was held in Innsbruck, Austria.

Known as the Regional Atmospheric Modeling and Data Assimilation System or

RAMDAS for short, this advanced system will be the first of its kind in the world. Slated for completion this fall, RAMDAS is a 4DVAR, or four-dimensional, variational system that is state of the art in integrating satellite observations with forecast models. The advantage of 4DVAR lies in its ability to provide the element of time along with the three spatial dimensions, for a more natural, or physically consistent way of bringing observations into the model. As Dr. Vukicevic puts it, "time is the key." The downside of 4DVAR is that it is very computationally intensive and can really only be done (if you expect results in a timely manner) using a collection of computers. A special cluster of PCs has been designated at CIRA for just this purpose.

What Makes RAMDAS Unique?

Several other forecast and research centers around the world have also been using the 4DVAR approach. RAMDAS is special in that it uses some of the most sophisticated models available to explicitly predict clouds. This will not only improve forecasts of clouds but has other benefits as well, such as potentially improving rain forecasts. RAMDAS will incorporate satellite observations not only in clear regions, which is done routinely by other forecast centers, but also in cloudy regions. No other center currently has this capability. In addition, the satellite observations will be used in RAMDAS as they are; they will not undergo pre-processing to transform the data into variables that the forecast model predicts. This pre-processing oftentimes produce biases, which can degrade forecast performance.

Part of the challenge the research team has faced in this effort is in making the connection between what the forecast model actually predicts (such as temperature and cloud water mass) and what the satellites observe (in this case, radiative energy). The goal then is to make the forecast model produce a two-dimensional field that mimics the satellite observations. The work just described has been the responsibility of Dr. Greenwald. He has been working with the most advanced models of the type referred to as radiative transfer models, which bridge the gap between the forecast model variables and the satellite observations. The accompanying figure (on page 11) illustrates a comparison of the visible reflectance observed by the GOES-9 imager and the 15-hour forecast of the visible reflectance for a cloud system over Oklahoma and Texas on May 2, 1996. Put simply, the 4DVAR system uses the differences between these two fields to make adjustments to the initial conditions of the forecast model, which should eventually lead to improvements in the forecast. In the research team's estimation and in view of our current knowledge, this is the best possible way to use the information content of the satellite observations and to provide the data to the model.

4DVAR in Action

The Zupanskis recently demonstrated how effective the 4DVAR approach could be in forecasting storms. Last year's East Coast snowstorm was famously over-hyped, and the weather forecasters were subsequently criticized for the no-show "storm of the cen-

(continued on page 11)

Weather Predictions *(continued from page 10)*

ture.” In their post analysis of this storm using an experimental 4DVAR system at NCEP and incorporating radar observations into the forecast models, the Zupanskis showed a dramatic improvement in forecasting the location of the highest snowfall accumulations (see page 12).

What’s in Our Future?

RAMDAS will remain a research tool for some time to come. It will be more than several years before a similar system is used in an operational setting. However, in the meantime the research team expects to learn much about the impact of satellite observations on forecasts, valuable knowledge that can be passed on in the development of future 4DVAR and satellite observational systems. The team’s desire is not only to provide new, sophisticated tools for doing research,

but also to become directly involved in educating graduate students in this emerging science. They expect to work closely with their colleagues at the Department of Atmospheric Science at CSU.

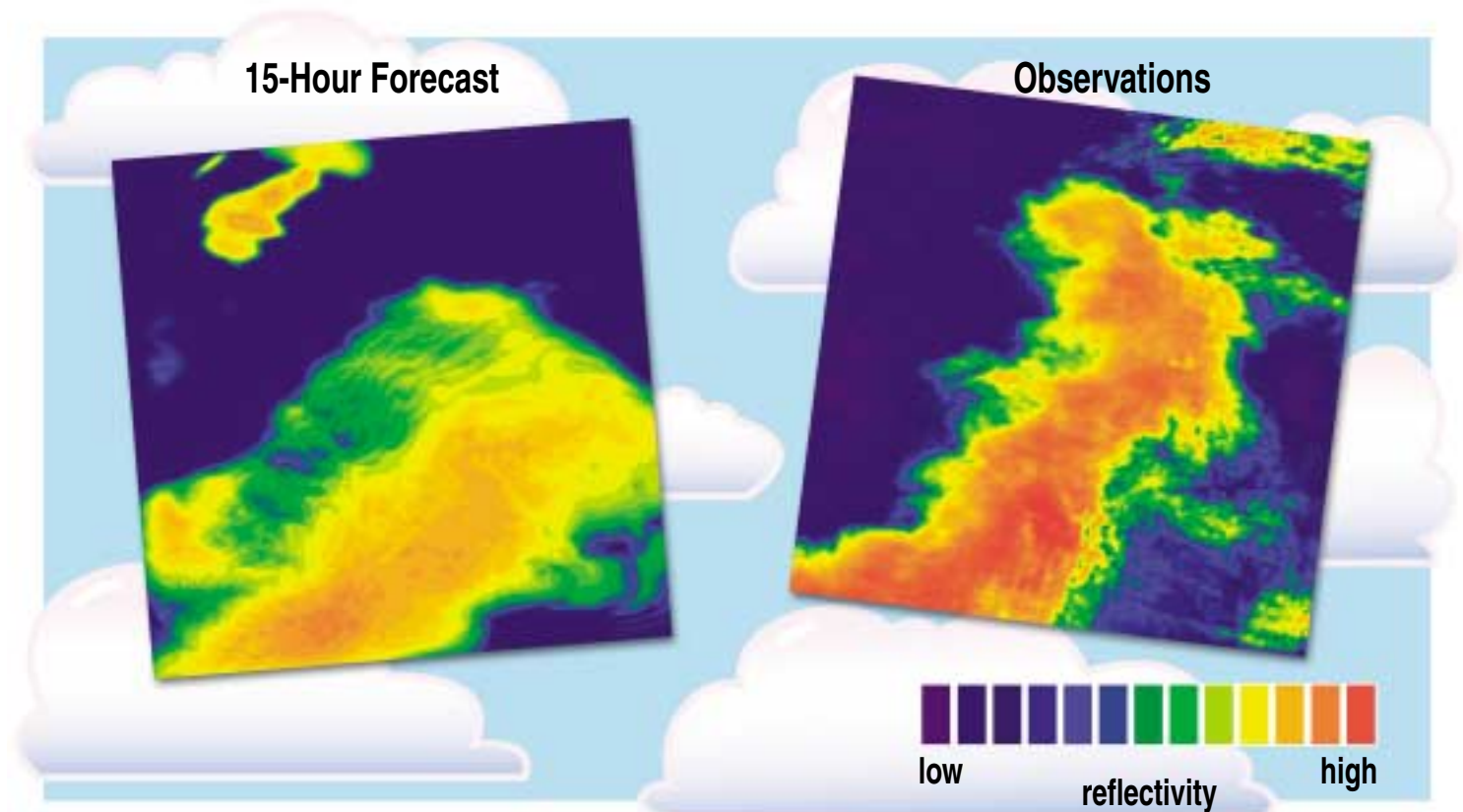
New satellite observing systems on the horizon will make available new information to the forecast models that current systems are unable to provide. For example, today’s satellite observations detect only limited information about clouds in terms of their vertical structure. With NASA’s Cloudsat project (to be launched in 2003) it will be possible to observe the vertical characteristics of clouds. CIRA will be the official data collection center for Cloudsat.

(continued on page 12)

$$\frac{d\phi}{dt} = -\vec{v} \cdot \nabla \phi - \phi \cdot \nabla \vec{v}$$

$$\frac{\partial \vec{v}}{\partial t} = -\alpha \nabla p - 2\vec{\Omega} \times \vec{v}$$

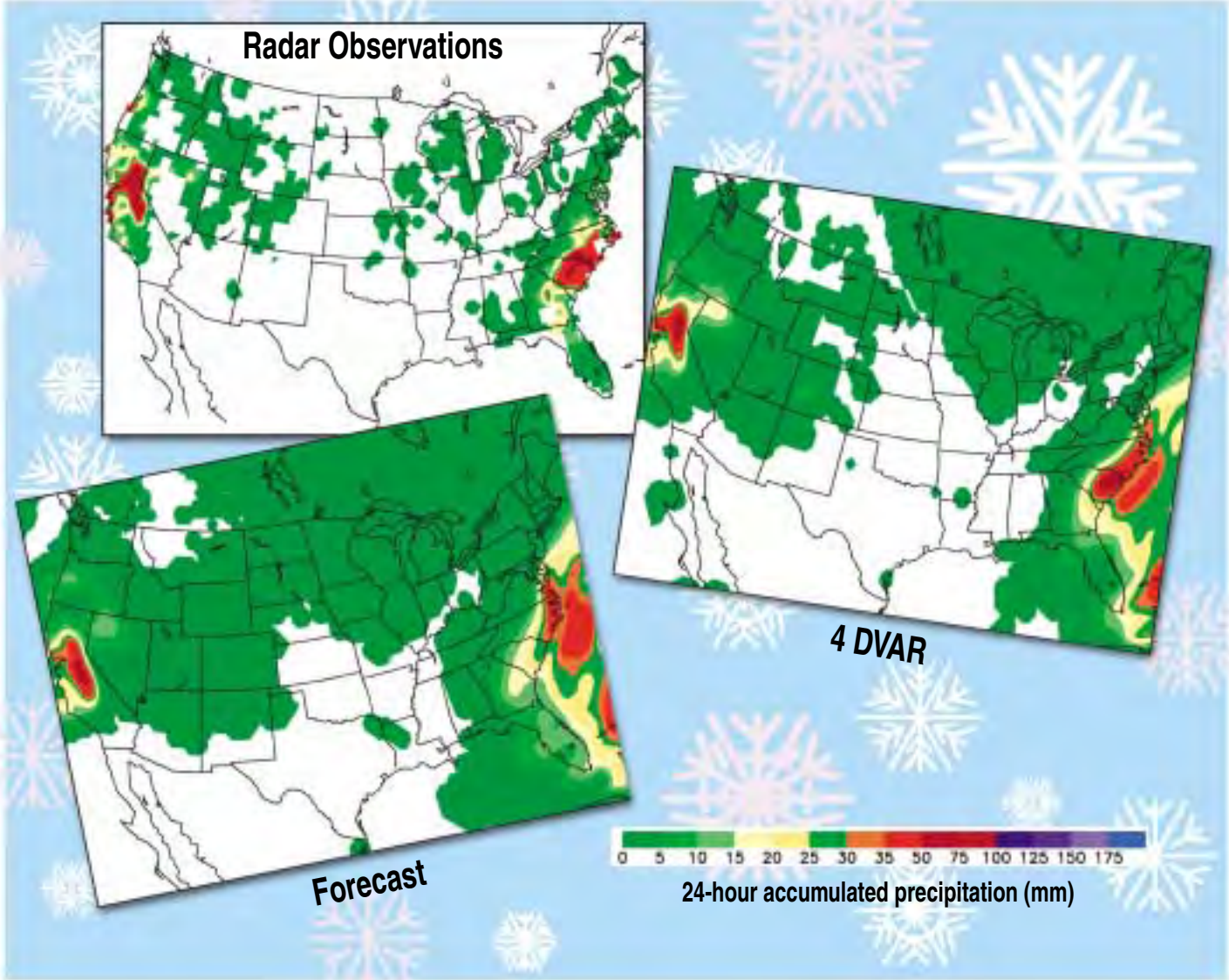
$$\frac{\partial \phi}{\partial t} = -\vec{v} \cdot \nabla \phi$$



A sample of RAMDAS’s ability to predict cloud reflectivity.

Illustration by Joe Greenwald.

Weather Predictions *(continued from page 11)*



4DVAR outperformed the National Weather Service forecast for January 2000 snowstorm.

Illustration by Joe Greenwald.

Improving Visibility: CIRA, WRAP, and the New Regional Haze Regulatory Program

By Doug Fox

For the past twenty years, the air quality group at the Cooperative Institute for Research in the Atmosphere (CIRA), supporting the National Park Service-Air Resources Division (NPS-ARD) and its leading physicist Dr. William Malm, have been studying visibility in National Parks and Wilderness Areas throughout the country. This research has helped to measure visibility and the aerosol constituents that degrade it, to quantify relationships between pollution sources and visibility impacts, and to identify the need for pollution control of major sources impacting specific National Parks.

Recently, visibility protection has gained importance through promulgation of regional haze regulations. CIRA's air quality scientists have been supporting the National Park Service assistance to the United States Environmental Protection Agency (EPA) in implementing these new regulations. In addition to developing Web-based data management and analysis tools, CIRA scientists are helping to develop guidelines, tools, and procedures for use by States, Tribes, and local air regulatory agencies that have to implement the regulations. Because regional haze results from many different emissions transported over long distances, EPA and the air agencies have decided to conduct regional haze technical support regionally and have formed five Regional Planning Organizations (RPO) to do it. CIRA has already been working with the Western Regional Air Partnership, WRAP, the first formal member of this group.

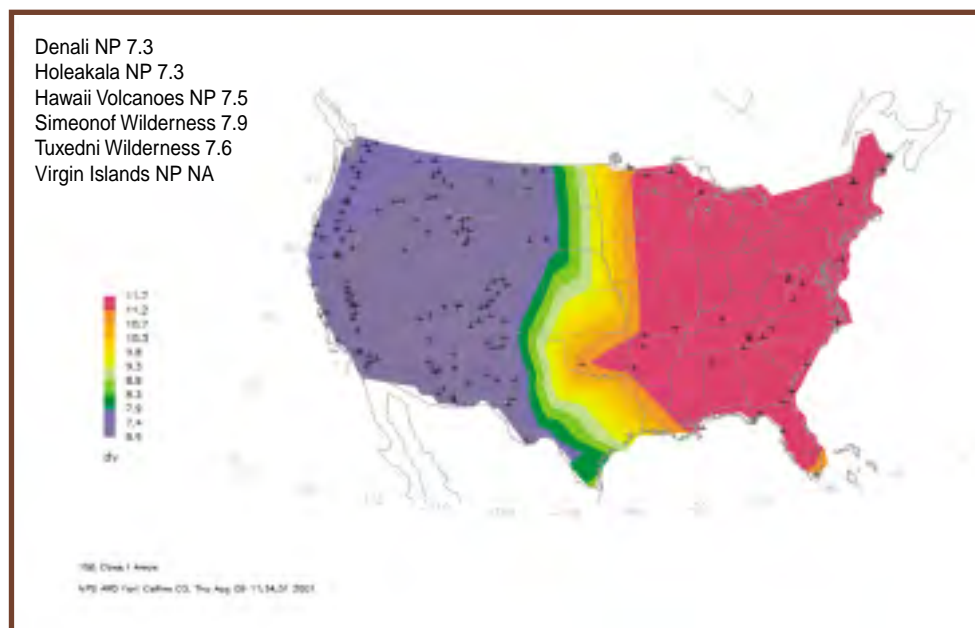
The Clean Air Act in 1977 established a national goal that visibility in National Parks and Wilderness Areas shall be free of any human-caused impairment. This goal applies specifically to 156 Class I areas, National Parks, and Wilderness Areas above certain size limits that existed prior to August 1997. Since then, the EPA along with the federal land managing agencies, National Park Service, Fish and Wildlife Service, and the Forest Service, have been working to characterize visibility, understand the causes of its degra-

ation, eliminate existing impaired visibility such as a specific source's plume blight, and ensure that proposed new sources will not cause any future visibility impairment.

CIRA staff members have provided technical support for the National Park Service visibility program since it began in the early 1980s. Through these years, CIRA's NPS group has assisted Dr. Malm in developing the IMPROVE (Interagency Monitoring of PROtected Visual Environments) national visibility monitoring network. IMPROVE measures parameters of visibility such as atmospheric extinction with transmissometers and light scattering with nephelometers. The network is used to collect aerosol samples and analyze them to estimate visibility. Aerosols are collected every third day with three distinct modules to allow chemical speciation

plot spatial patterns, and develop temporal trends. CIRA staff have also been involved in a series of intensive field programs at Grand Canyon, Great Smoky, Shenandoah National Parks and, most recently, Big Bend National Park, where basic new understanding of aerosol properties are investigated and where new monitoring techniques are tested.

Now, the past twenty years of work by Dr. Malm, the CIRA staff, and their professional colleagues is bearing fruit. The results of IMPROVE visibility and aerosol monitoring have clearly established that all Class I areas in the United States experience impaired visibility due to regional haze. And the IMPROVE measurements have become the official tool for determining the status of visibility and tracking progress toward improving it. Mixed, well-aged aerosols from a



This graphic illustrates estimated natural visibility at the 156 Class I areas, in deciviews for the 20% worst visibility days.

and size separation (less than 10 and less than 2.5 micrometers in diameter). CIRA scientists analyze the IMPROVE aerosol data, calculate relationships between the measured chemical constituents and measured optical parameters,

wide variety of sources cause regional haze. Primarily scattering by ammoniated sulfate, ammonium nitrate, organic carbon, soil and coarse mass and adsorption by elemental

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CIRA Communiqué: Employee News

High School Teacher Works with CIRA

By Nolan Doesken

In June 2001, Mr. Renny James joined CIRA and the CSU Department of Atmospheric Science for a short two-week stint as a research meteorologist. Mr. James, the only science teacher at Liberty School, a tiny rural school, grades K-12, in eastern Colorado, teaches everything from biology and chemistry to earth science. Although confined to a wheel chair for much of his life, Mr. James continues to look for ways to learn as much as possible about the world he lives in so that he can share that knowledge with the young people of the communities where he grew up (Kirk and Joes, Colorado).

His research has included investigations of localized rainfall patterns in eastern Colorado during the summer of 2000. He, along with several of his students, had helped collect data on rainfall and hail as a part of the Community Collaborative Rain and Hail Study (CoCo RaHS) and the Severe Thunderstorm Electrification and Precipitation Study (STEPS). One of his findings was that even though the summer of 2000 had been very dry across much of Colorado, rain still managed to fall somewhere in the four-county area near his home in east-central Colorado on nearly 2/3 of the days during the eleven-week period of intensive data collection. But he also learned that days when heavy rains were reported (one inch or more at any location) also tended to be days when precipitation fell over most of the area. Isolated storms, in general, produced less precipitation.

While doing research, Renny also had time to participate in seminars, a special “Kids in College” program that other CIRA employees were conducting, and spent time learning how to access and view the myriad of meteorological satellite data gathered at CIRA. When asked if he had learned anything from his two-week internship, Renny enthusiastically replied, “Wow, I sure did!” Kids at Liberty School had better look out – when school begins this fall. They will all be expected to be scientists.



CIRA intern, Renny James, during his two-week internship as a research meteorologist.

NOAA “Team Member of the Month”

James Ramer, a research associate with CIRA/ Boulder, was recently named NOAA’s Team Member of the Month. Ramer works with the Forecast Systems Laboratory and was recognized for his contributions to the Advanced Interactive Processing System (AWIPS).

Ramer was recognized by NOAA Research for excellence on five levels – “his deep understanding of the science of meteorology; clear comprehension of the needs of operational forecasters; exemplary knowledge of real-time computer software and systems; exceptional work ethic; and great team spirit.” The citation noted that Ramer’s developments have increased the effectiveness of day-to-day oper-



James Ramer

ations of National Weather Service forecast offices nationwide.” It continued: “Ramer almost single-handedly designed and developed some of the most important and heavily used components of AWIPS. These include both tools and techniques used to display an almost unlimited combination of numerical model fields and the Warning Generation Application, which has revolutionized and accelerated the way forecasters issue severe weather warnings to the public.”

“Federal 100” Award Winner from CIRA:

Alexander “Sandy” MacDonald
Director, Forecast Systems Laboratory
CIRA/Boulder



Alexander “Sandy” MacDonald

Federal Computer Week, a Government IT publication, recently presented one of their “Federal 100” awards to Sandy MacDonald. MacDonald installed the first Linux-based supercomputer in the federal government – used to test new weather models for forecasts – giving the agency the 34th fastest computer in the world for a cost that did not come close to equaling the top 100 budgets for such computers.



Other News of Note:

Dr. Yuanfu Xie, collaborating with the Director’s Office at the NOAA Forecast Systems Lab, has been awarded a “fellowship” under the Japan Society for the Promotion of Science (JSPS) Invitation Fellowship Program for Research in Japan. As part of the award, he has been invited to conduct research with the Meteorological Research Institute of the JMA for 3 weeks this fall. He’ll be working with the head of MRI (Dr. Hajime Nakamura) on the 3DVAR scheme involving GPS data.

Second Annual CIRA Research Award Winners Announced

Once again, CIRA management was pleased to present a number of CIRA employees with the recognition they deserve for innovative research. The award, designed to recognize outstanding research initiative or achievement, is based on a number of rigorous criteria. This year's winners include the FX-Net team (whose innovation was featured in the last issue of the CIRA newsletter), and two individuals, one from the Boulder office and one from the Fort Collins office.

Dr. John Knaff, Dan Schaffer, and the FX-Net team comprised of Dr. Renate Brummer, Sean Madine, Dr. Ning Wang, Evan Polster, John Pyle, and Amenda Stanley.



John Knaff joined CIRA in May 1999 as a Research Associate collaborating with the NOAA/NESDIS RAMM Team on various research related to tropical cyclone analysis using satellite data. His innovative research efforts fall into the following five areas: 1) Development and application of wind retrieval algorithms using Super-Rapid Scan Operations GOES imagery; 2) Use of GOES sounder data for tropical cyclone genesis forecasting; 3) Development of a real-

time AMSU processing system for tropical cyclone analysis; 4) Lead on the GOES-11 science test; and 5) Development of real-time intensity forecasting algorithms for the National Hurricane Center and the Joint Typhoon Warning Center.

Dan Schaffer joined CIRA in October 1998 as a Research Associate supporting the Advanced Computing Branch in the Aviation Division of NOAA/Forecast Systems Lab (FSL). Since his arrival, Dan has been a key member of the team that is developing software for the FSL's Scalable Modeling System (SMS). SMS greatly simplifies the job of making numerical models run efficiently on cost-effective, massively parallel supercomputers. This past year, Dan was responsible for parallelizing several weather and ocean models, including the NOAA Aeronomy Laboratory's (AL) atmospheric chemistry model and the Rutgers University's Regional Ocean Modeling System. According to Dr. McKeen, the lead scientist at AL, the time required to run NALROM has been reduced from five days to four hours!



Renate Brummer joined CIRA in 1995 as a Research Associate and was promoted to Research Scientist in 1999. In addition to her responsibilities as the project manager for the FX-Net Initiative, she



is also the program manager for GLOBE – the extremely successful international environmental research program that links the efforts of students, teachers, and scientists around the world. The program has grown from 500 U.S. schools in 1995 to more than 10,000 participating schools in over 95 partner countries. FX-Net – a network-based, real-time display system featured in the Spring 2001 issue of the CIRA Newsletter – was developed with the meteorological workstation needs of research and teaching facilities, fire weather forecasters, and remote weather service offices in mind. Under her outstanding technical oversight and guidance, this innovative project has matured from an embryonic idea four years ago into a robust, operational system. The list of project accomplishments includes the initial installation at Plymouth State College in 1999 and its selection for support of the outdoor venues of the 2002 Winter Olympics in Salt Lake City.

Sean Madine joined CIRA in October 1995 as a Research Coordinator in the International Division of FSL. As the technical lead for the complex FX-Net project from its inception, his outstanding technical leadership, imagination, and dedication have been the key to its successful design, development and deployment. The most significant milestone for this project was achieved when Sean successfully installed an operational FX-Net server at the NWS Western Region Headquarters in Salt Lake City to support the 2002 Winter Olympics. This is the first time that an FX-Net server was installed outside FSL and the first time that an FX-Net server has been communicating directly with an operational NWS AWIPS data ingest system.



Ning Wang also joined CIRA in October 1995 as a Research Coordinator in the International Division of FSL. He recently earned a Ph.D. from the University of Colorado at Boulder in Computer Science. As the senior developer on the FX-Net project and an expert on data compression and performance optimization, the application of a “wavelet transform” technique for compressing satellite and model imagery that he

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developed was the key contribution that made it possible to deliver AWIPS-type capabilities over the Internet. He is now heading a development effort focused on the compression of multi-dimensional gridded forecast model fields using a new processing scheme based on wavelet transform.



Evan Polster joined CIRA in April 1999 as a Research Coordinator in the International Division of FSL. He has been an indispensable member of the team, especially in the design and development of crucial new components for the FX-Net client-user interface. He's the lead on investigating and testing newly available commercial software applicable to FX-Net development and operations. Evan also is responsible for teaching and training new team members

and FX-Net users regarding its architecture and functionalities.

John Pyle joined CIRA in December 2000 as a Research Coordinator in the International Division of FSL. He became a specialist on the FX-Net server component and immediately began making significant contributions to the project. John successfully converted the FX-Net server software from HP UNIX to PC Linux. The conversion resulted in a noticeable improvement of the server robustness and performance. He also took on the task of getting to know the very complicated commercial InstallShield software. This new expertise made it possible to release "professionally packed" FX-Net client software, which results in extremely simple installation of the user software.



Amenda Stanley joined CIRA in February 1997 as a Research Coordinator in the Facility Division of FSL. In addition to her involvement in a number of major data acquisition, management, and distribution projects within FSL's Central Facility, Amenda's contributions to the FX-Net project have been particularly noteworthy. She was responsible for tailoring and integrating several AWIPS data servers into the Central Facility systems architecture to provide

reliable and responsive data flow for the FX-Net clients across the country. The robustness of the system running operationally at locations such as Plymouth State College and at the 2002 Winter Olympics in Utah is a testament in part to her vital contributions.

CIRA's Role in the "Kids in College" Program

Nancy Hartley, the Dean of Applied Human Sciences at Colorado State University, and her assistant, Barb Wallner, coordinate a summer enrichment program for local school children in grades 4 through 8. Among the subject areas to which students are exposed are science, math, and the arts. Many academic departments participate in Kids in College (KIC) by providing lessons and fun activities to enhance learning. This summer marked the second consecutive year that CIRA has lent a hand to KIC largely due to the generous efforts of Nan McClurg and Kelly Dean.

sions to give students a broad look at atmospheric science. Each session was grouped by age: 4th, 5th, and 6th graders, then 7th and 8th graders in another. This summer two sessions were conducted and each ran for three hours Monday through Friday.

Among the activities Dean and McClurg planned for a typical day were cloud watching and cloud identification using scientific names and terminology, daily temperature readings and a comparison with historic weather facts, and keeping daily records of other weather-related observations. A weather satellite receiver was connected to a PC to collect



Thomas Chen among some other KIC participants at work with Nolan Doesken of CSU Atmospheric Sciences.

The idea behind KIC is to provide workshops and other means such as interactive lessons, games, computers, videos, discussions, and guest speakers and even some arts and crafts to get students to "turn on" to learning. CIRA's contribution, entitled "Weather Research," included daily activities, talks, and discus-

the APT image from the NOAA and Russian weather satellites as they flew overhead, revealing the current weather situation from above. A computer display of the most recent tornado, thunderstorm, and flood warnings issued by the NWS Offices across the country provided the location of

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the most severe weather as it was happening. Each day the students heard a different speaker who would share his/her expertise in a particular field of research such as tornadoes, thunderstorms, hurricanes, lightning, and an overview of the Colorado Climate Center's rain and hail study (CoCoRAHS program). Through on-line games and puzzles the participants tested their skills and knowledge on weather-related science facts and through video tapes, guest speakers, and discussions, they learned about severe weather, do's and don'ts if caught in severe weather, as well as the causes of severe weather. Hands-on activities like a craft or a project where the kids worked together usually filled the last 30 minutes of the day.

The impact of such a program on these young minds is significant. One participant,

11-year-old Ryan Unangst, shared that after the program he had a new appreciation of the subject: "I never thought it [weather] was so cool before...!" He explained, "We learned about different kinds of clouds, and different weather instruments, like hail pads and rain gauges and how they work. Dr. Petersen taught us about different kinds of lightning like cloud-to-cloud, cloud-to-ground, and blue jet lightning that goes above the clouds. One person talked about flash floods and the Fort Collins flood, and how within just the city, some parts of town had 2 inches of rain while others got 10 inches. Dean had us look at the computer that tracked all of the weather satellites, and we talked about the GOES (Geostationary Operational Environmental Satellite) and the POES (Polar Operational Environmental Satellite)."

Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference 2001

CIRA, on behalf of the Army Research Lab, hosted this year's BACIMO Conference at the University Park Holiday Inn in Fort Collins on 10-12 July. The conference objective is to enhance cooperation and coordination in all aspects of atmospheric, weather, and cloud impacts on military operations among U.S. military services, the civilian community, and other nations. Sessions at this year's conference covered battlespace sensing techniques & applications, tactical decision aids, clouds, measurement & modeling of EO parameters, measurement of clouds and cloud parameters, meteorological modeling/data assimilation, and atmospheric propagation. The keynote speaker was Captain Frank Garcia Jr., USN, Assistant for Battlespace Environments, Deputy Undersecretary of Defense for Science and Technology. Nearly 100 participants from research laboratories, operational military agencies (U.S. and NATO), and universities were in attendance. Web site for agenda and additional information is at: www.cira.colostate.edu/GeoSci/Bacimo2001/

Director's Sabbatical; Interim Director Announced

CIRA's Director, Dr. Thomas H. Vonder Haar, announced on August 8th that he will be taking sabbatical leave during the academic year 2001-2002. In his absence, Emeritus Professor Dr. Thomas B. McKee of Atmospheric Science at Colorado State University will serve as the Acting Director.



According to Dr. Vonder Haar, the sabbatical is designed as a time of "research immersion," during which his work will focus on CIRA-related activities as well as a few new areas of personal interest. "My trips will be interspersed through the next year (a few weeks up to two months each). I'll [also] be spending considerable time with the research and the professional development of my graduate advisees." During the period, Dr. Vonder Haar has said that he would encourage on-going communication with research and research-related questions and ideas since that is the theme of this sabbatical.



Emeritus Professor Thomas McKee of Atmospheric Science was a professor and research leader at CSU for 26 years beginning in 1974. He was the first Colorado State Climatologist and also served as Department Head from 1984-89. Dr. McKee and other colleagues specialized in regional climate studies, mountain-valley circulations, radiative transfer and remote sensing. Dr. McKee's relationship with CIRA has been long-standing both as a member of the Advisory Council and as a research project leader. Thus, he brings a great deal of CIRA, CSU and national research perspective to his Acting Director position.



Improving Visibility *(continued from page 13)*



Photo of the IMPROVE site in Glacier National Park. Visible are the three different modules collecting aerosol for chemical speciation.

carbon or soot cause haze. The sulfates and nitrates are hygroscopic, i.e. they attract so much water that a relative humidity factor needs to be considered. Regional haze is sufficiently well characterized by this set of six components to visibility that the EPA has based their new regulatory program on it.

The visibility calculation is based on IMPROVE data. Detailed guidance on how to do the calculations will be issued by EPA this fall. In preparation for this guidance and formal regulatory application, IMPROVE has expanded its network to 150 sites throughout the United States and representative of all of the Class I areas. The regulations will establish the current baseline visibility condition using a five-year monitoring period, 2000-2004. Visibility will be calculated in deciviews (dv), a scale based on the natural logarithm of the measured extinction coefficient, $dv = 10 \ln(\text{bext}/10)$. Bext is calculated from the six measured aerosol components mentioned above and a relative humidity factor. The regulation considers five-year means of the 20% best and the 20% worst visibility days. Specifically, the regulation requires that the five-year mean of the 20% best days not degrade and the five-year mean of the 20% worst days improve. The rate of improvement is based on comparing existing (measured) visibility with estimated “natural” visibility for each Class I area. The regulation

requires that air regulatory agencies establish policies to achieve the estimated natural visibility by 2064. In other words, if the 2000-2004 measured five-year mean of the 20% worst visibility days is 30dv and the estimated natural condition is 10dv, the agency must establish policies to improve the visibility a total of 20dv over the next 60 years, or 1.67dv each five year period. The policies

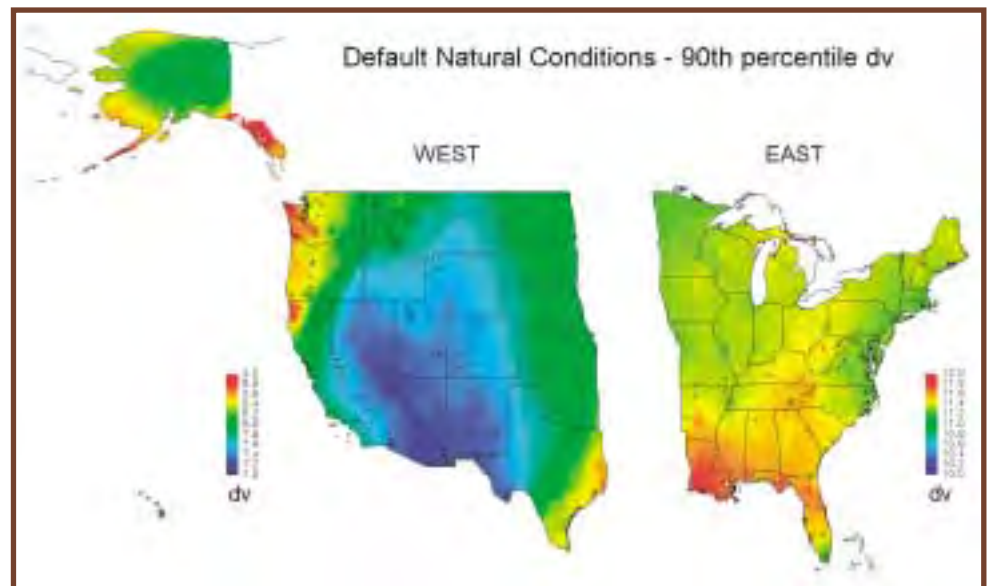
are the responsibility of the individual regulatory agencies, but the Clean Air Act requires that they be legally enforceable.

CIRA scientists are working with the EPA to ensure that the IMPROVE data are sufficiently quality assured to be used for this important regulation. They are helping EPA develop the appropriate calculation procedures and are assisting in evaluating and documenting them. Over the past year, the CIRA air group has conducted training sessions for three of the Regional Planning Organizations and developed training material to support the regulations.

Among the many questions about visibility that continue to attract the attention of CIRA’s air quality group, one is particularly challenging. Namely, how can the natural visibility of each Class I area be determined? The law is explicit that its goal is to prevent future, and remedy existing, man-made visibility impairment. Thus, natural is what remains after human-caused pollution is removed. In the guidance being issued this fall, EPA will propose estimates of this natural visibility based in part on research and analysis by CIRA air quality scientists.

It is likely that the estimate of natural visibility will attract a great deal of attention.

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A comparison of natural visibility in deciviews in the eastern and western U.S.

Improving Visibility *(continued from page 18)*

The estimates are based on a national assessment of natural background aerosol concentrations done more than 10 years ago. This assessment identified background values of the six components in the visibility equation: one set of values applicable to the East and another applicable to the western United States. The natural background for each of the 156 Class I areas is estimated from the assessment data adjusting it with relative humidity factors from a new climatological analysis of relative humidity. While these represent a reasonable and equitable starting point, it is almost certain that the air agencies will want to conduct additional analyses to capture local conditions such as influences of sea salt and forest burning.

The natural visibility levels, the hygroscopicity of the organic aerosol, along with a number of other issues, such as the specific sources of the organics and the extent to which they are primary (directly emitted) or secondary (generated in the atmosphere by photochemical and within cloud reactions), remain gaps in our understanding.



Close-up of a typical IMPROVE aerosol sampler. Each of the three different modules collect fine particulates on different media and are subjected to various chemical analyses to characterize the amount of chemical species in the air.

Hails and Farewells at CIRA

Below is a list to acknowledge those who have recently joined our research organization, and those for whom opportunity has 'knocked' elsewhere. Best wishes to all.

Those who've joined us:

Christopher MacDermaid, Research Associate – Boulder Facility Division
Quanhua Liu, Postdoc – Camp Springs, Maryland
Mark Sleeper, Coordinator – Boulder NGDC
Milija Zupanski, Postdoc – Fort Collins
Dusanka Zupanski, Research Associate – Fort Collins
Lisa Gifford, Coordinator – Boulder Aviation Division
Darren McKague, Research Associate – Fort Collins
Richard Ryan, Research Coordinator – Boulder Facility Division
Mike Barna, Research Associate – National Park Service

Those who've moved on:

Cyril Mehta, Coordinator – Boulder Modernization Division
Todd Smith, Coordinator – Fort Collins, NOAA/NESDIS/RAMM Team
Yahya Golestani, Research Associate – National Park Service, Fort Collins
Rolf Hertenstein, Research Associate – Fort Collins
Scott Longmore, Research Associate – Boulder Modernization Division
Christopher Adams, Research Scientist – Fort Collins
Gerard Murray, Coordinator – Boulder Systems Development Division
Richard Grubin, Coordinator – Boulder Facility Division
David Serke, Coordinator – Boulder NGDC
Jamie Riggs, Research Associate – Boulder Facility Division
Julie Schenk, Coordinator – Boulder International Division
Bob Hufziger, Administrative Assistant II – Director's Office, Fort Collins
Tom Dotts, Coordinator – National Park Service

CIRA Mission

The Cooperative Institute for Research in the Atmosphere (CIRA), originally established under the Graduate School, was formed in 1980 by a Memorandum of Understanding between Colorado State University (CSU) and the National Oceanic and Atmospheric Administration (NOAA). In February 1994, the Institute changed affiliation from the Graduate School to the College of Engineering as part of a CSU reorganizational plan.

The purpose or mission of the Institute is to increase the effectiveness of atmospheric research of mutual interest to NOAA, the University, the State and the Nation. Objectives of the Institute are to provide a center for cooperation in specified research programs by scientists from Colorado, the Nation and other countries, and to enhance the training of atmospheric scientists. Multidisciplinary research programs are given special emphasis, and all university and NOAA organizational elements are invited to participate in CIRA's atmospheric research programs. Participation by NOAA has been primarily through the Oceanic and Atmospheric Research (OAR) Laboratories and the

National Environmental Satellite, Data, and Information Service (NESDIS). At the University, the Departments of Anthropology, Atmospheric Science, Biology, Civil Engineering, Computer Science, Earth Resources, Economics, Electrical Engineering, Environmental Health, Forest Sciences, Mathematics, Physics, Psychology, Range Science, Recreation Resources and Landscape Architecture, and Statistics are, or have been involved in, CIRA activities.

The Institute's research concentrates on global climate dynamics, local-area weather forecasting, cloud physics, the application of satellite observations to climate studies, regional and local numerical modeling of weather features, and the economic and social aspects of improved weather and climate knowledge and forecasting. CIRA and the National Park Service also have an ongoing cooperation in air quality and visibility research that involves scientists from numerous disciplines. CIRA is also playing a major role on the NOAA-coordinated U.S. participation in the International Satellite Cloud Climatology Program (part of the World Climate Research Programme).

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If you know of someone who would also like to receive the CIRA Newsletter, or if there are corrections to your address, please notify us.